
Three Diphoton Results from CDF

Cross Section • Peaks Search • MET Search

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Diphoton Triggers and Selections

Triggers

- $2 \times \text{Et} > 12$, w/cal iso
- $2 \times \text{Et} > 18$, wo/cal iso
- high-mass search includes high-Et very loose trigger

Main Cuts

- Central ($|\eta| < 1.0$) only
- Had/EM
- Cal Iso, cone 0.4
- shower in CES, χ^2
- leading track Pt
- track isolation, cone 0.4
- second CES cluster Et

Searches

- $|\eta| < 1.0$
- $< 0.055 + \text{sliding}$
- $< 2 \text{ GeV}$
- < 20
- $< 1 \text{ GeV}$
- $< 2 \text{ GeV}$
- $< 2 \text{ to } 3 \text{ GeV}$

Cross Section

- $|\eta| < 0.9$
- $< 0.055 + \text{sliding}$
- $< 1 \text{ GeV}$
- < 20
- $< 0 \text{ GeV}$
-
- $< 1 \text{ GeV}$

MEt search adds anti-cosmic cuts on Hadron TDC times,
topology, unattached muon stubs

All analyses use $Z \rightarrow ee$ and minbias to study/correct ID efficiencies

Cross Section - BG subtraction

Primary background

- $\pi^0 \eta$, and other multi-photon clusters
- can only be subtracted on a statistical basis

$E_t < 35 \text{ GeV}$, CES

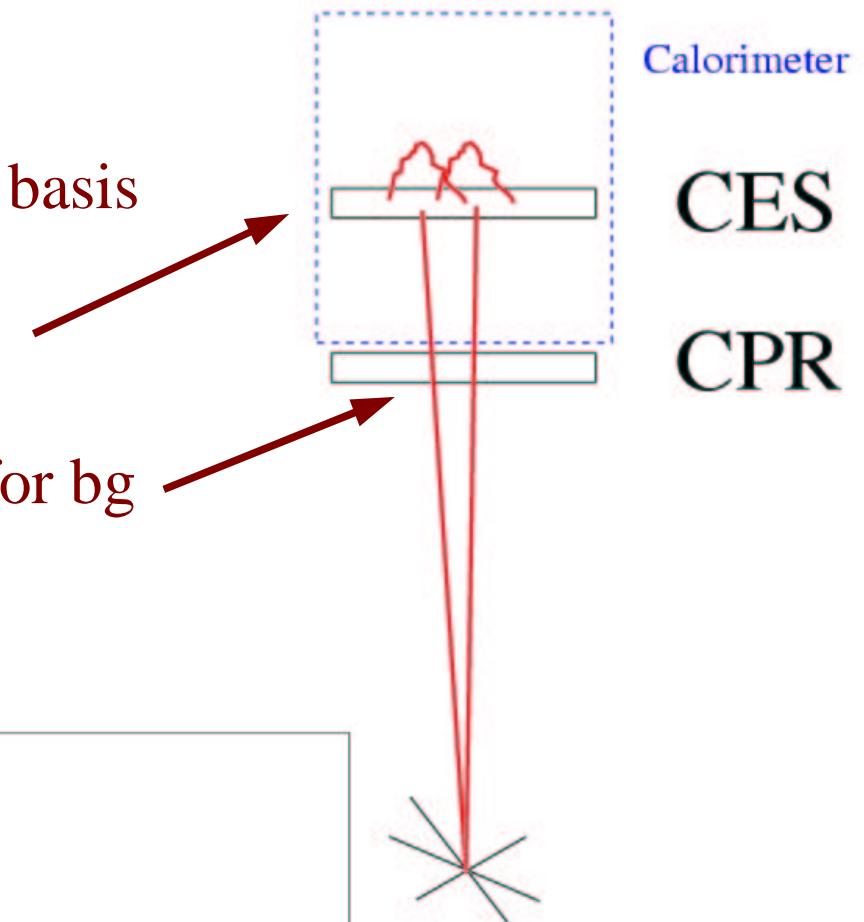
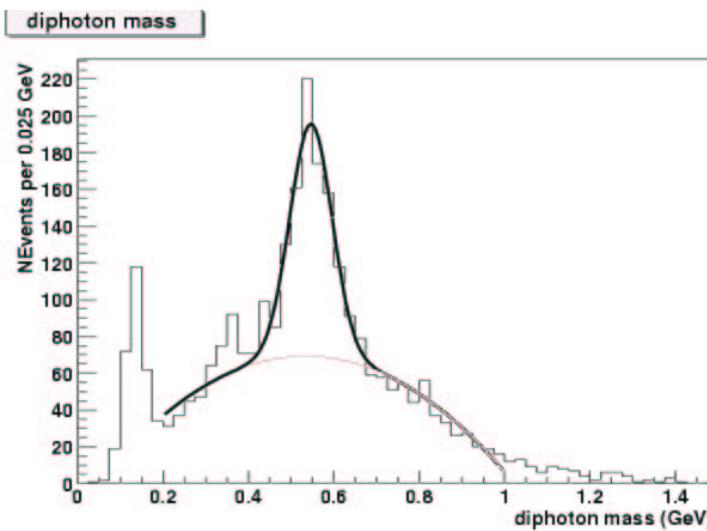
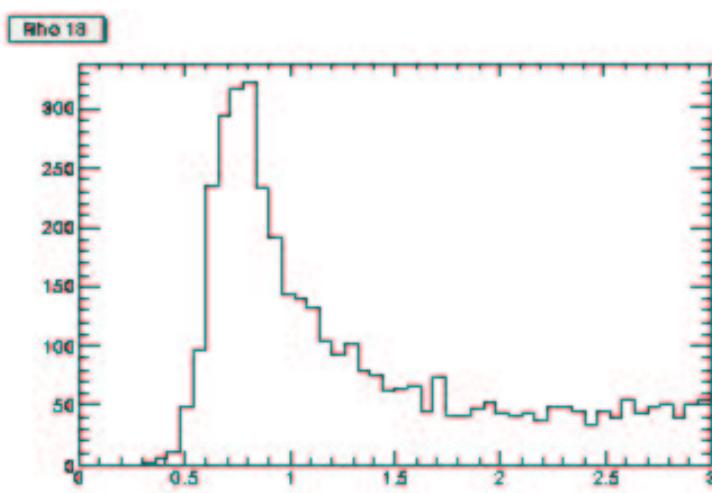
- shower-max can detect larger clusters

$E_t > 35 \text{ GeV}$, CPR

- preradiator detects more conversions for bg

Validated

- Control samples, ρ , η , and isolation



Diphoton Cross Section

Sample

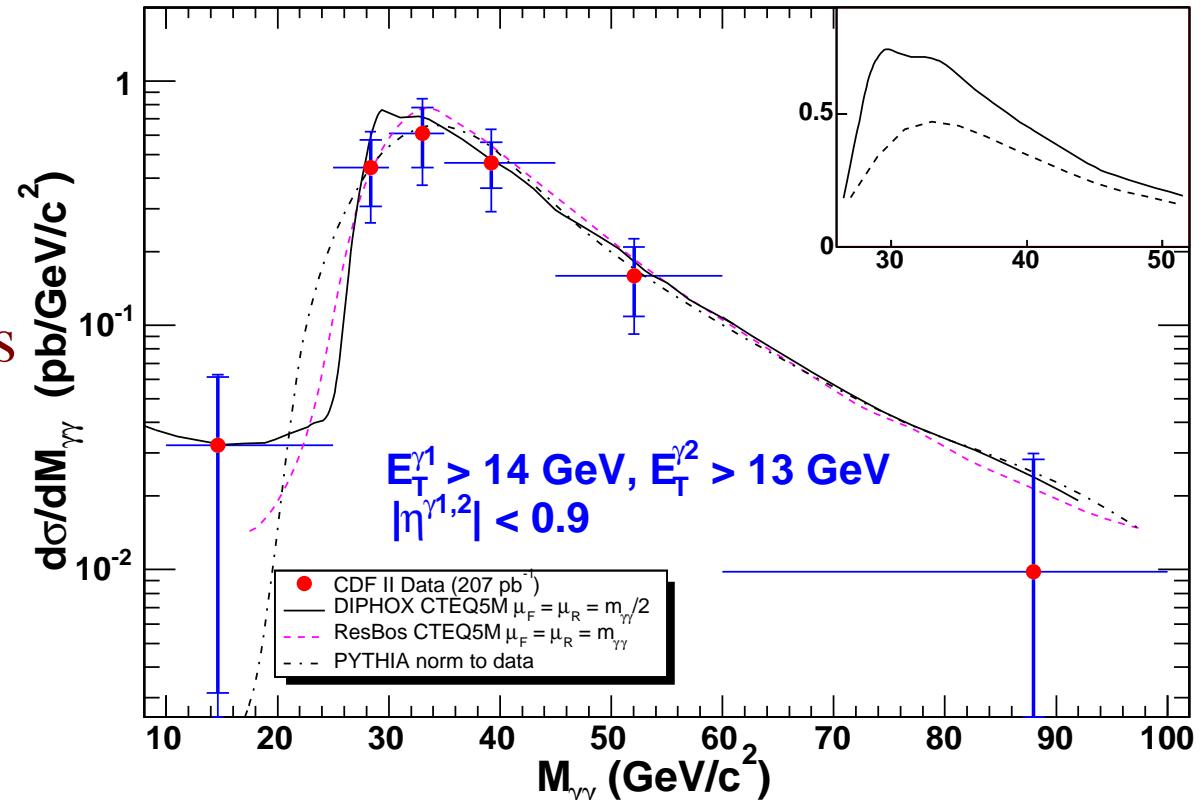
- 207 pb^{-1}
- $E_T > 13, 14 \text{ GeV}$, $|\eta| < 0.9$
- Tight photon ID cuts
- $426 \pm 59 \gamma\gamma$ in 889 events
- bg substr. dominates uncertainty

Compare Pythia

- All LO + ISR model
- scaled $\times 2$ for plots

Compare RESBOS

- LO + $q\bar{q} \rightarrow \gamma\gamma$ at NLO
- soft g ISR resummed



Balazs *et al.* Phys. Rev. D **57**, 6934 (1998)

Binoth *et al.* Eur. Phys. J. C **16**, 311 (2000)

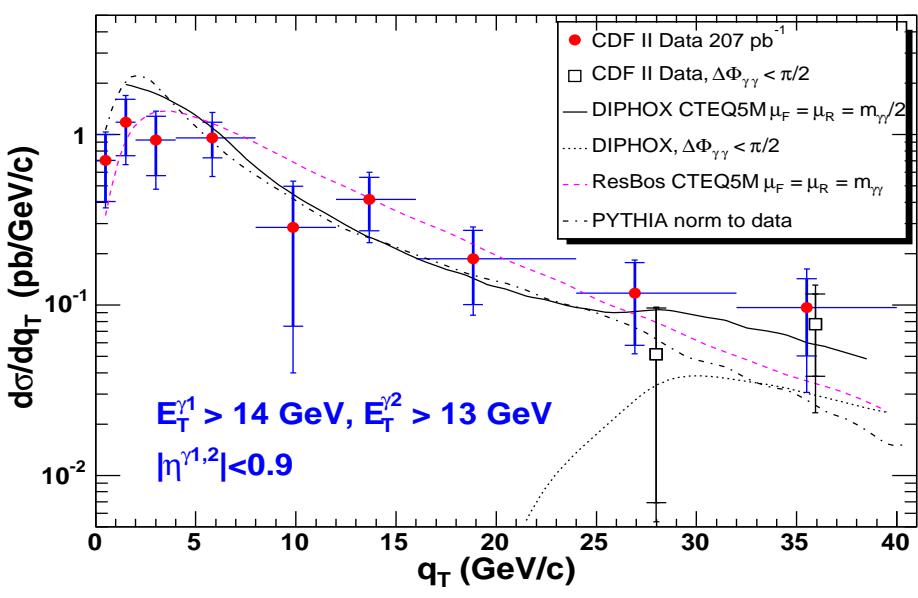
Bern *et al.* Nucl. Phys. Proc. Suppl. **116**, 178 (2003)

Compare Diphox

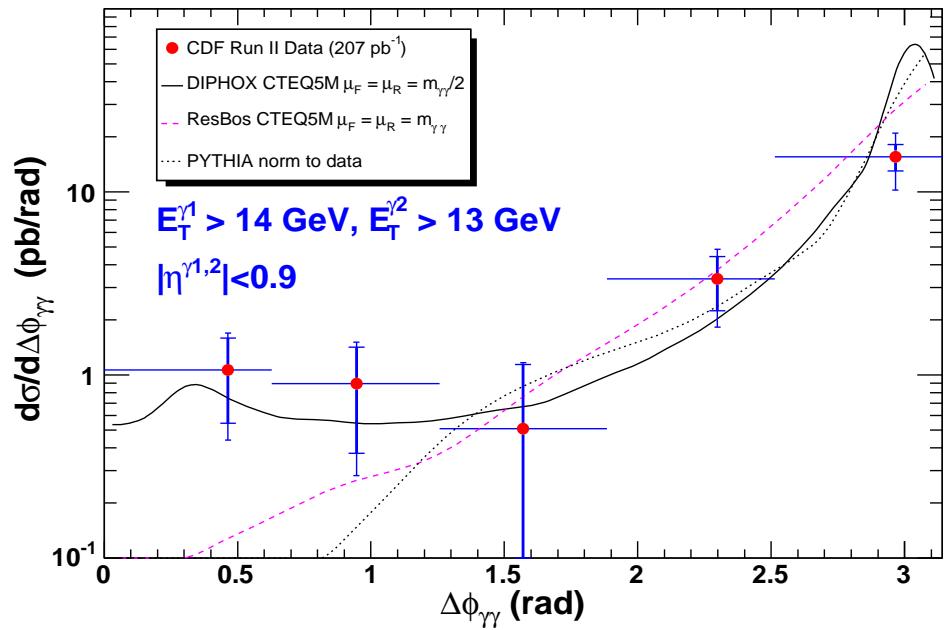
- All NLO but $gg \rightarrow \gamma\gamma$ box
- $gg \rightarrow \gamma\gamma$ NLO added by us

Diphoton Cross Section

qt = diphoton system Pt



$\Delta\phi$ between photons



- Diphox breaks down at low q_T due to singularities in NLO
- RESBOS does better at low q_T due to continuous ISR resumming
- diphox shows additional source at low $m(\gamma\gamma)$, small $\Delta\phi$, and $q_T > 30$ GeV
these are ($qg \rightarrow gq\gamma \rightarrow g\gamma\gamma$) where the q fragmented to a photon

Search for Diphoton Peaks

Model

- Randall-Sundrum Gravitons
- Extra dimension is "warped", warp factor k
- S-channel Graviton yields $ee, \mu\mu, \gamma\gamma$ peaks at high-mass

Analysis

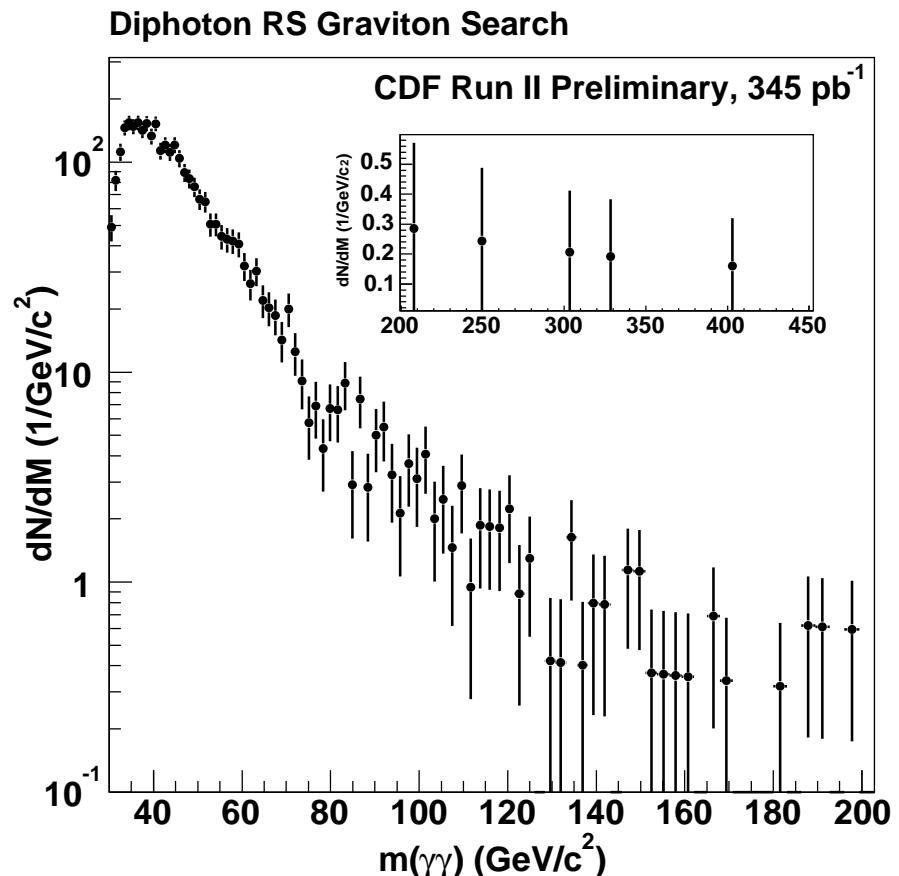
- 2 Central γ ($|\eta| < 1$), $E_t > 15$ GeV
- Mass > 30 GeV

High-Mass Events

Mass: 207 248 305 329 405

$\cos \theta^*$: 0.47 0.09 0.33 0.08 0.52

- no sign of cosmics

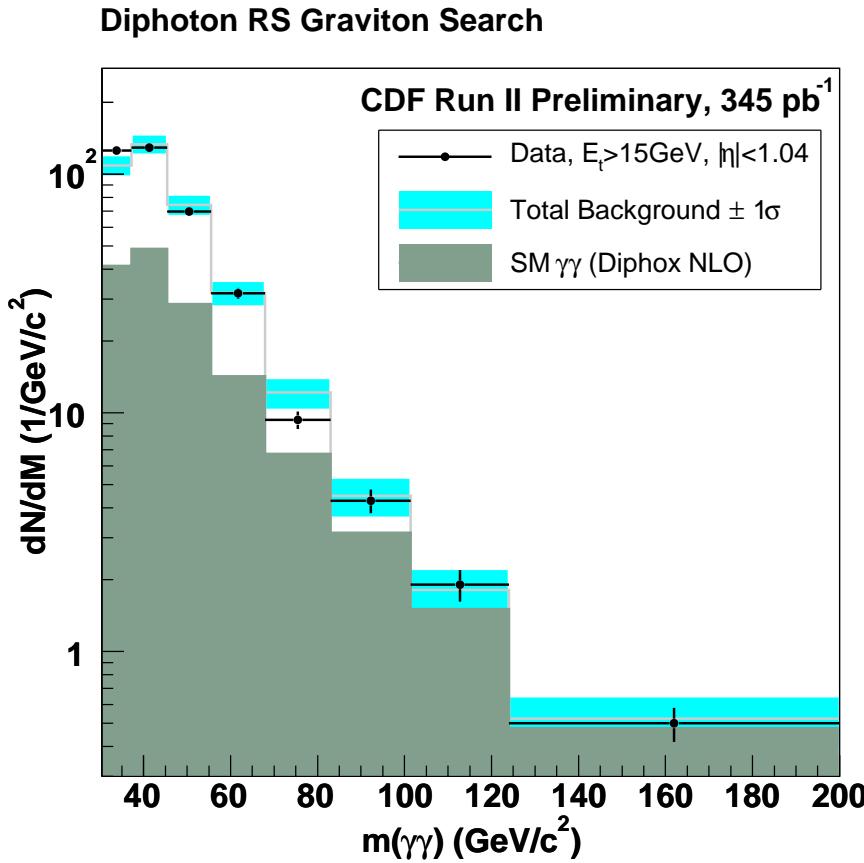


$\gamma\gamma$ Mass in bins of
 1σ mass resolution

Search for Diphoton Peaks

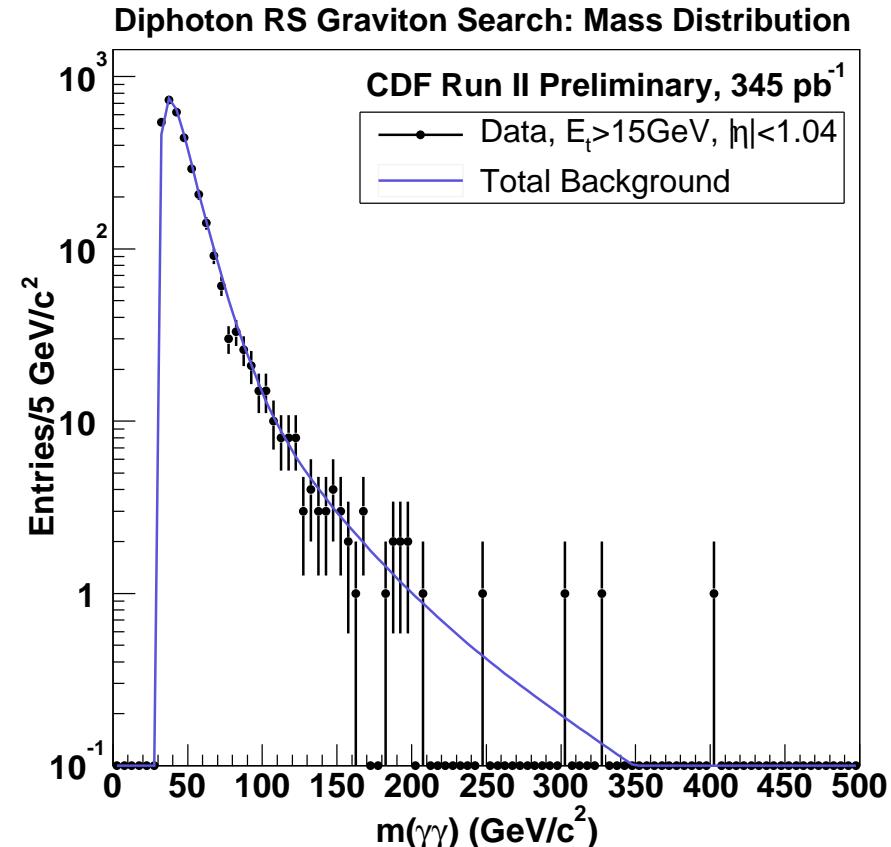
SM Diphoton background

- NLO Diphox calculation
- normalized to \mathcal{L}



Jets Faking Photons

- Mass shape from a sample of loose diphotons
- normalized to low Mass



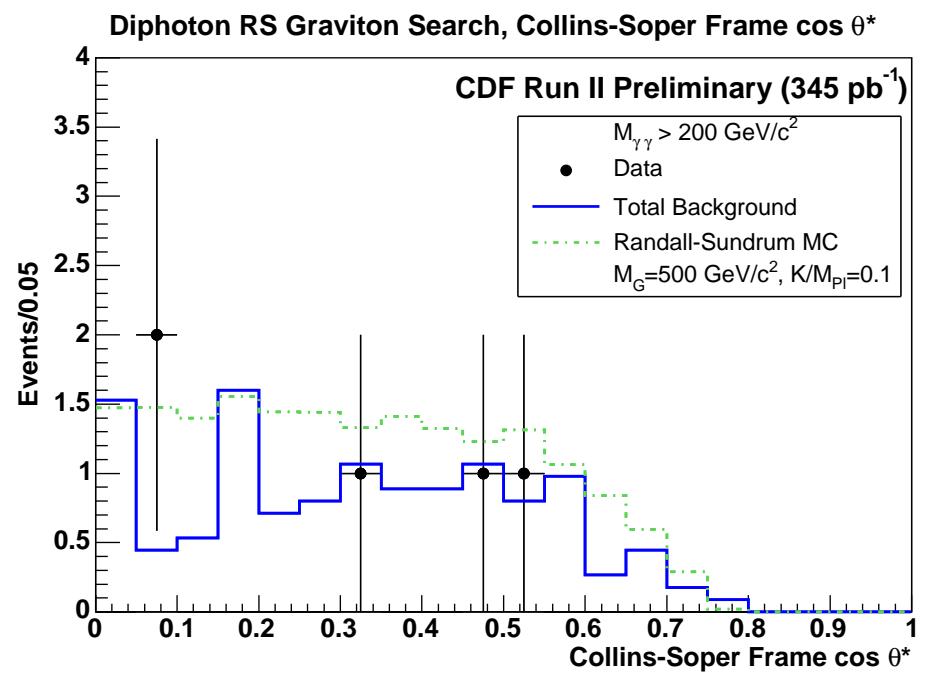
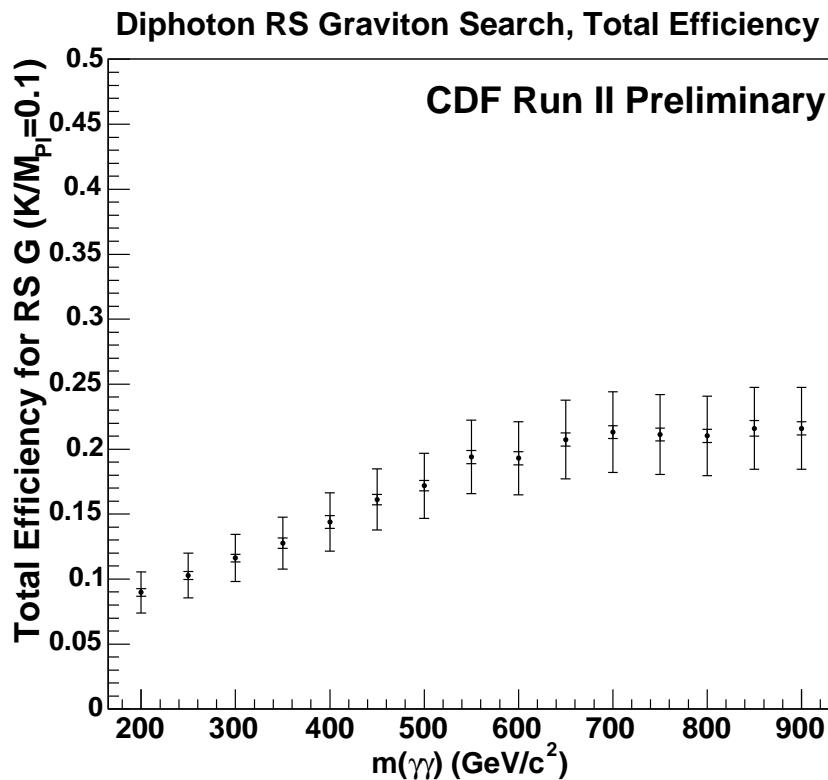
Diphoton Peaks Search - A•ε

Acceptance times efficiency

- Pythia 6.223, reweighted for spin-2 particle
- losing 6% per leg to conversions!

Spin Effects

- $\cos \theta^*$ can be sensitive to some models
- not included in limits



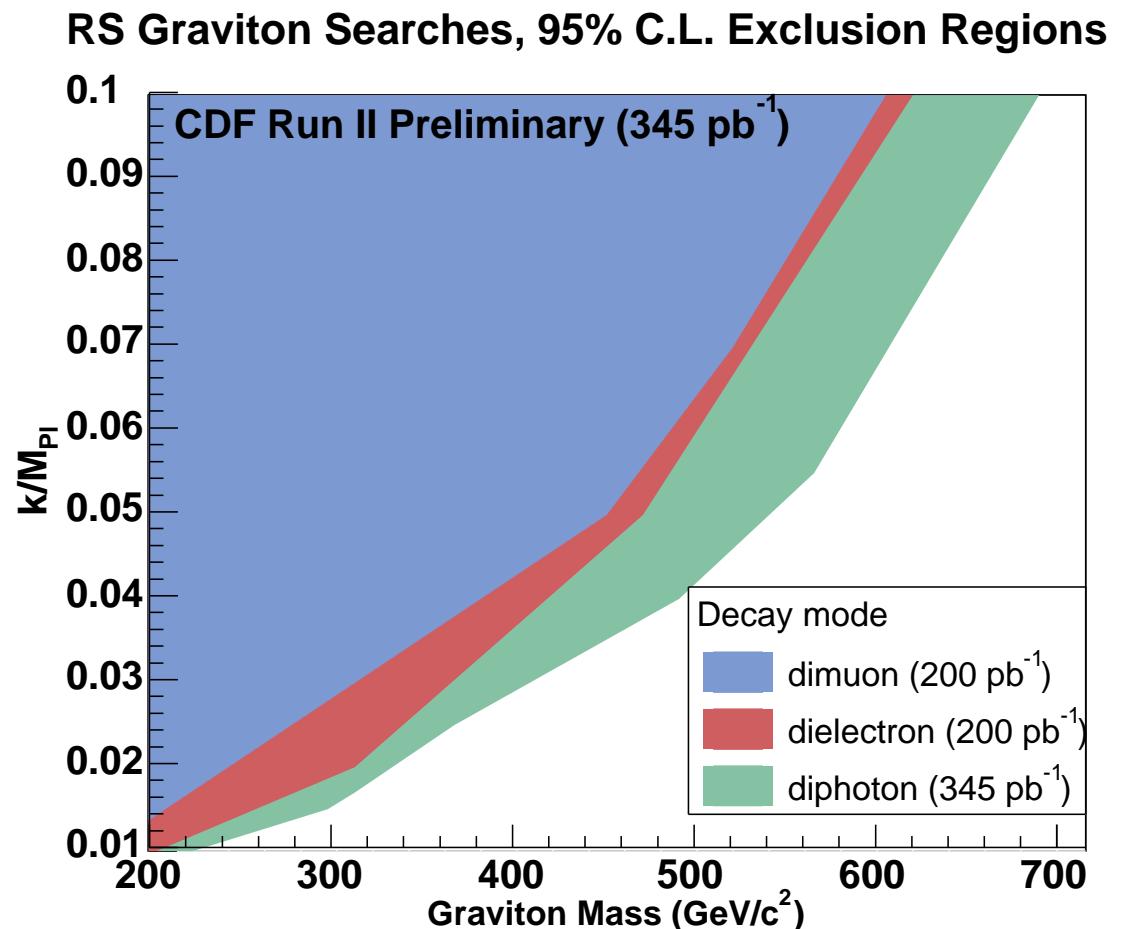
Randall-Sundrum Graviton Limits

Limits

- $k/M_{Pl}=0.1$, $M(G)>690$ GeV
- $ee, \mu\mu \sim 200$ pb,
 $\gamma\gamma 350$ pb
- $\gamma\gamma$ has larger BR
- $\gamma\gamma$ spin factors improve acceptance

Acceptance Potential

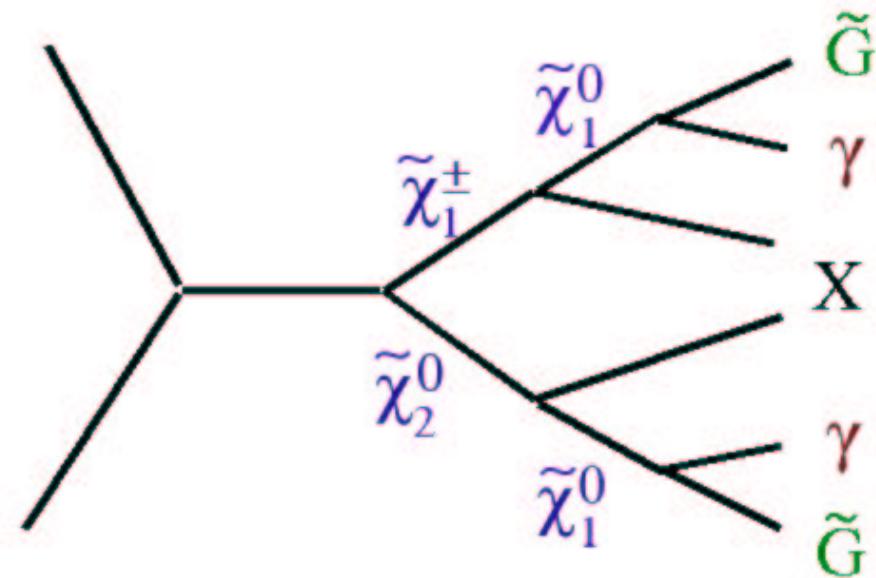
- $\gamma\gamma$ combined with ee
- accept conversions
- add plug ($x2$ at high- η)



Search in Diphoton and Met

Model

- Gauge-Mediated SUSY Breaking Snowmass model
(Allanch et al. Eur Phys. J. C25 113 (2002))
- Lambda parameter scales masses
- Largest cross section C1-N2 and C1C1
- all production leads to events with diphotons and MET
- X not used in analysis



High-Et

- Median MET 70GeV
- γ Et : 60/30 GeV

Diphoton and Met - Backgrounds

- Optimized MET > 45 GeV

Standard Model

- Diphoton production
- Jets: π^0 faking a photon,
shape from loose diphotons
normed to low MET

$$0.01 \pm 0.01 \pm 0.01$$

e γ , with e faking a photon

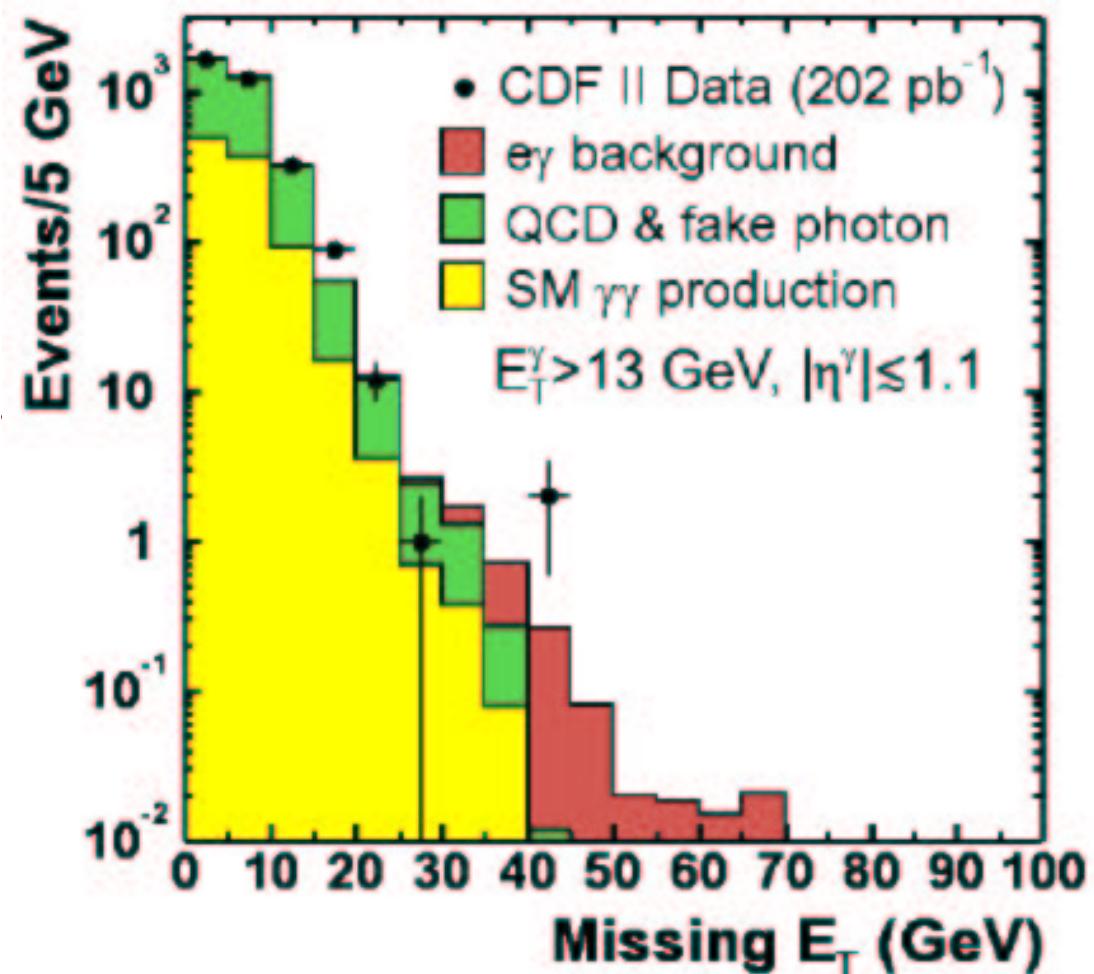
observed e γ fake rate

$$0.14 \pm 0.06 \pm 0.05$$

cosmics

derived from control samples

$$0.12 \pm 0.03 \pm 0.09$$



Total: $0.27 \pm 0.07 \pm 0.10$

Observed: 0

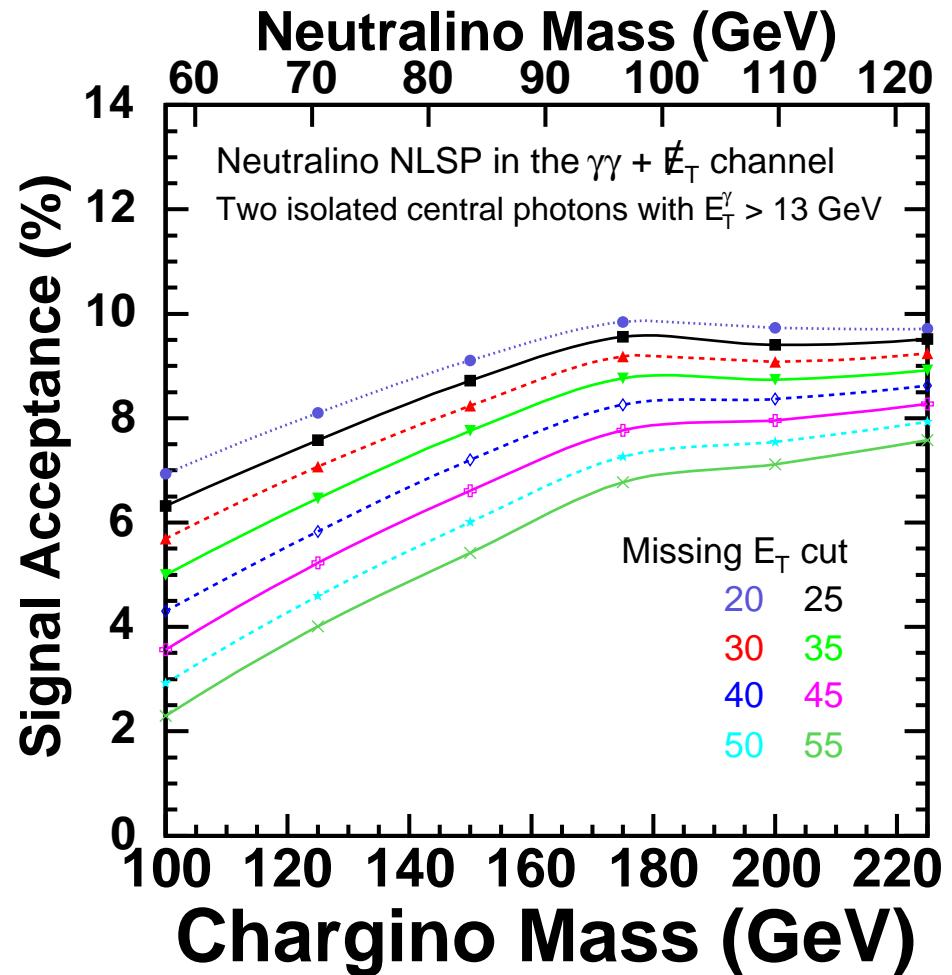
Diphoton and Met - Efficiencies

Acceptances

- ISAJET 7.51
- for $M(C1)=175$, $A = 32\%$
(E_T , and central Cal fiducial)

Efficiency

- GEANT simulation
- inefficiency due to X spoiling isolation is significant
- for $M(C1)=175$,
and $MEt>45$ GeV, $\epsilon = 23\%$



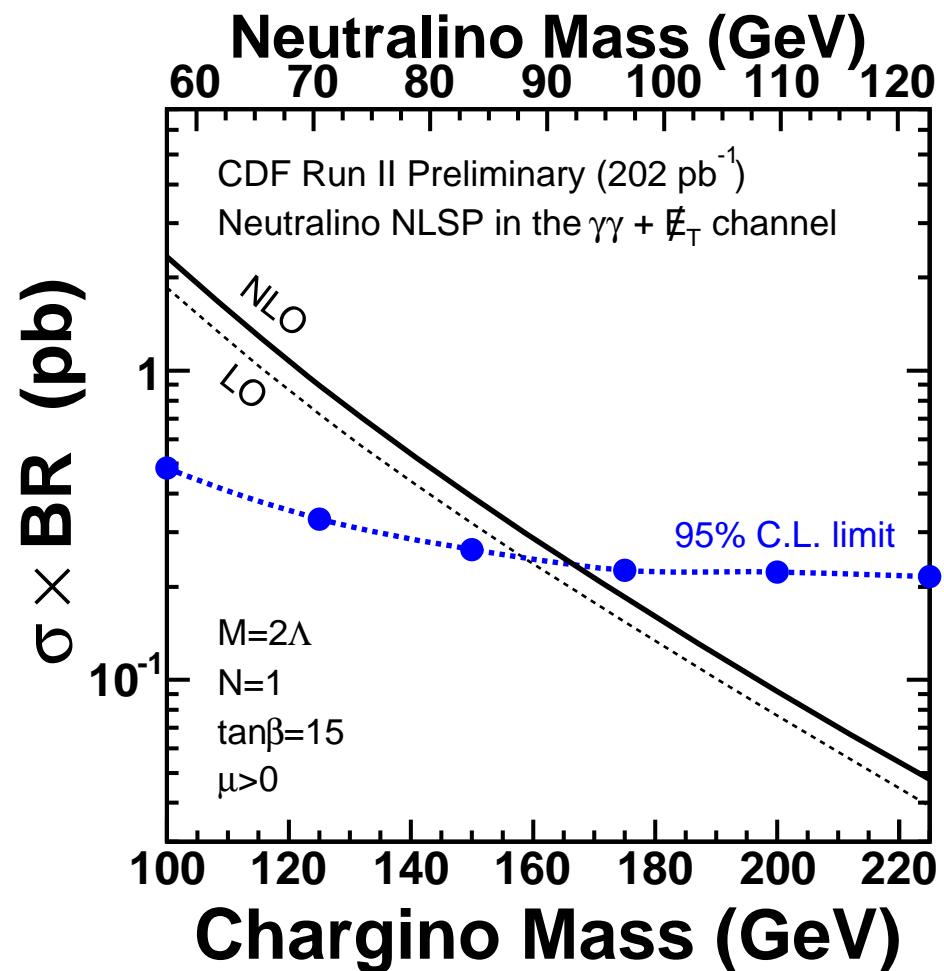
Diphoton and Met - limits

Limits

- NLO (+ ~20%)
from Prospino
- background subtraction
0 events observed
- Bayesian methods

Snowmass GMSB model

- $M(C1) > 167 \text{ GeV}$
- $M(N1) > 93 \text{ GeV}$
- $\Lambda > 69 \text{ TeV}$



Last Slide

DiPhoton Cross Section

- Consistent with NLO Diphox
- Interesting comparison with generators

Diphoton Peaks Search

- Data well-modeled by background estimates
- Set limits on R.S. Gravitons

Diphoton and MET Search

- Central, $E_t > 13$, $MET > 45$, 0 events observed
- $M(C1) > 167$ GeV in Snowmass GMSB Model